

# Ubiquitous Computing in a Web 2.0 World

By Glen Bull and Bill Ferster

In the third wave of computing, people will interact with multiple computers in multiple ways in every setting. Schools are not yet approaching a ratio of one computer per student, much less the multiple computers per person envisioned in Weiser's third wave of ubiquitous computing. However, students are increasingly gaining access to computers outside of school. Recent studies show the vast majority of teenage students have access to the Internet outside of school. Nearly 90% have access in their own home, 75% report using the Internet at a neighbor's house, and 61% report using the Internet in a public library. The trend appears to be access to multiple computers in multiple locations.

## Ubiquitous Access to Apps and Data

The value of ubiquitous computing is enhanced and reinforced by another trend: the transition to a Web 2.0 world. Tim Berners-Lee designed the Web for static presentation of data. In a Web 2.0 world, applications and data reside on the Web itself. A Google search yields more than 10 million references to "Web 2.0," one indication of the level of interest in this topic.

Google itself is an early illustration of the potential of a Web 2.0 environment. Google mail (Gmail) was one of the first and best examples of a Web-based application that approximates the interactivity of an application running on a local microcomputer. Google Maps soon followed, illustrating the rich user-interface possible in a Web 2.0 environment.

Author Tim O'Reilly sponsors an annual Web 2.0 Conference. He predicts that future Web 2.0 word processors will support wiki-style collaboration while simultaneously supporting the rich formatting found in PC-based applications. This article was written in Writely (<http://www.writely.com>), an early example of a Web-based word processor that supports collaborative writing. We used Writely to simultaneously work on this article over the Web at separate locations more than 100 miles apart.

## Portable Hardware, Software, and Content

The Apple iPod is an example of the intersection of ubiquitous computing and Web 2.0. Its user-centered design

"Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives."

—Mark Weiser,  
former chief technologist  
Xerox PARC

is responsible for its widespread adoption: The device is portable, a pleasure to use, able to accept audio and other content from many sources, and open to innovation by others.

The iPod lives in an ecosystem, with some parts physically created by Apple (the device itself, iTunes, and a database of music accessed through the Web), and some in collaboration with the existing infrastructure (complicated relationships with the record companies). It offers the ability for others to build on the ecosystem and leverage these capabilities in ways Apple did not foresee, using standards such as MP3 and RSS protocols (podcasts).

Apple's iPod is a success—literally ubiquitous—because it offers capabilities people want. It is important to note that this transcends hardware. The iPod is focused on the idea that

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Prototype digital movie generator on PBS Civil War Site (<http://www.pbs.org/civilwar/>)

people want to have their music available whenever and wherever they are. This requires software that partly lives on the Web and digital content (a deep catalog of songs).

Other MP3 players sometimes have hardware features the iPod lacks such as FM radios, built-in microphones, and so on. However, none has approached as seamless a connection of hardware, software, and content.

### Web 2.0 Schools

How can we enhance schools in an era in which computing is becoming ubiquitous outside the classroom but is still constrained within? The first and most important lesson is that it is not just about hardware—building better MP3 hardware or providing a laptop to every student. It is about access to Web-based software and content as well.

Schools face a significant barrier that inhibits effective use of computers: limited access to effective software designed for educational use. School licenses seldom grant the right for students to install software outside of school. Even when licenses grant this right, public libraries and other sites used by students generally do not welcome installation of external

software. Consequently, few teachers are able to make class assignments involving software designed for their subject areas.

A Web 2.0 approach can change this equation. Students will be able to access applications from any computer connected to the Internet. Their work will be saved on the Web as well, making it possible for them to begin an activity in school and continue working in other locations—home, a neighbor's house, or the public library. However, teachers need more than adaptations of generic business tools adapted for teaching, such as Web-based word processors. They need applications designed for specific content areas.

### Subject-Specific Web Applications

An instructional example developed for the PBS Teacher Source Web site foreshadows the potential of a Web 2.0 environment. The site, developed to accompany Ken Burns' Civil War film, offers students the opportunity to assemble historic images and documents into a digital movie.

Social studies teachers have found that construction of these kinds of digital history narratives can result in high levels of student engagement. But, the initial PBS prototype has sev-

eral limitations. For example, students choose from one of only two prerecorded narrations to accompany the film. It is possible to envision future tools that will allow students to record their own narration for the digital story they construct.

This approach is perfectly suited to an era in which students are becoming increasingly comfortable with re-mixing media and manipulating playlists. In a Web 2.0 environment, it will be possible to access the resulting media creations on the Web or on extensions such as the video-enhanced iPod.

### Approaches to Instruction

The majority of students already have access to multiple computers outside of school. Few schools provide a computer for every student, but most classrooms have an Internet connection. We anticipate that computer projectors will soon become standard in every classroom. What are the possibilities under these conditions?

A social studies teacher with an Internet connection and a projector could conceivably develop a digital movie with a class of students using different sequences as a springboard for inquiry and class discussion. Because the application and content are Web-based, students could subsequently develop individual movies using any computer from any location with an Internet connection.

Under some conditions, it may be desirable for each student to develop an individual movie in class. But even when we enter an era in which every student has a computer, whole-class discussion and inquiry will still be valuable at times. Currently, when one-to-one student-computer ratios are still more the exception than the rule, we can leverage increasingly widespread access outside school by thoughtful development of Web-based applications and content. The capabilities

for developing rich, interactive applications on the Web are becoming possible at a time when they are most needed.

### Conclusions

Beyond a rich interface approaching the interactivity of a PC-based application, other Web 2.0 characteristics include what O'Reilly terms an "architecture of participation" in which users are co-developers and applications become more valuable the more they are used by harnessing a collective intelligence. Teachers and students will be involved in the design and evolution of successful instructional tools. Social elements, such as collaborative capabilities that harness students' use of instant messaging, may well be incorporated into the first successful Web 2.0 application for schools as well.

Ubiquitous computing, then, not only implies access to hardware in every location, but access to Web-based software and data and user collaboration as well. The transition to a Web 2.0 world is occurring even as this is written. We now need more examples of Web 2.0 software for specific subject areas modeling effective educational use of this emerging capability.



Education (<http://www.CITEjournal.org>).

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